APPENDIX F
CLEANUP LEVEL EXTRAPOLATION

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During the initial Footprint Studies, arsenic concentrations were still above the 20 mg/kg clean up level at the boundary of the study area. Arsenic concentrations were assumed to decay exponentially away from the smelter in the 2002 study. Therefore, the distance to the 20 mg/kg concentration level was estimated by fitting an exponential curve to the upper limit of the data (a straight line in a log-linear plot). Using the upper limit is a more conservative method than the median and 90th percentile approaches used in Figures 1 through 7 of this report. The method is presented in Attachment B of the Tacoma Smelter Plume Site, King County Mainland Soil Study (Glass, 2002).

The 2002 method was reproduced using data from the Extended Footprint Study to assess its applicability to the few areas identified in Section 5 where arsenic concentration had not decreased below 20 mg/kg. In addition to the newly available data, all data between 0 and 6 inches was used to improve extrapolations.

Equations for the exponential bounding curves used in the 2002 King County study (Glass, 2002) were used to calculate the estimated distance to the 20 mg/kg arsenic concentration for the E, ENE, N, NE and NNE spokes (Table F-1). The 2002 study used these equations to calculate distance to the 100 ppm level. There is a small error in using the 2002 equations to calculate from mg/kg rather than ppm due to differences in molar weight between matrix and arsenic. However, these errors are expected to be small relative to curve fitting errors and the net differences in estimated distance.

There is substantial variability between spokes of the wind rose in the degree to which an exponential curve fits the upper limit of the data. In NW-SE directions, where wind frequency is lower and concentrations decrease more rapidly, exponential curves generally provide a good fit to the upper limit of the data. The upper limit of the data is more complicated in spokes of the wind rose that are along dominant wind directions which traverse bodies of water, have limited sampling areas, or encounter topographic relief. For example, the northeast spoke of the wind rose shows variations in arsenic associated with bodies of water including Puget Sound, Lake Washington and Lake Sammamish and topographic relief near Interstate-90 (Figure F-1). Exponential curves do not provide a satisfactory upper bound in the northeast direction. Concentrations form a rough plateau at 30-50 mg/kg from 15 to 40 miles with localized variations near bodies of water. A bounding exponential curve was fit to all data to estimate a distance of 53.6 miles, but there is significant uncertainty in that estimate due to the poor fit and the plateau in arsenic concentrations mentioned above.

Comparison of estimated distances to the 20 mg/kg limit in the N through E wind rose spokes indicates that estimate distances have increased along all spokes (Table F1). Increases between the 2002 study and this study range from 24 to 155 percent. It is interesting to note that the 2002 estimates are within 5 miles of the last observed analysis reported above 20 mg/kg in 4 of 5 wind directions. However, when the 2002 technique is applied to the current data compilation, the discrepancy between estimates is considerably larger. Discrepancies in distance estimates are qualitatively observed to increase with the number of complicating factors along the wind direction, such as topographic relief and large bodies of water.

Sources of Error

Differences between the distance to the 20 mg/kg limit calculated by this and the 2002 study to some degree may be attributable to inclusion of a larger data set encompassing a larger geographic area in the analysis. However, there are also problems in applying a simple bounding curve method to this complex data set:

- As indicated in Figures F-1, the upper limit of data in plots is often not linear in log-space and using an exponential projection is of questionable validity. This complexity is observed along other wind directions as well.

- Plotting a line through the maximum values only uses a small percentage of the data and does not take advantage of the full power of the data.
- The method does not account for complex wind patterns which may occur in the Puget Lowlands, the effects of water bodies, and topographic relief. Additionally, site disturbance, vegetation, slope aspect and other factors can reduce arsenic concentrations at individual sites, reducing their utility for predicting regional distribution.

Considering that the distance to the 20 mg/kg limit increased for all extrapolations between the 2002 study and the current study, it is likely that any estimates made with the current data set would also increase upon further data collection.

The variability between adjacent spokes and in association with bodies of water and specific site conditions indicate that a more sophisticated model for describing the distribution of arsenic concentrations may be a better predictive tool than an exponential bounding curve, as presented here. More sophisticated models may include the use of atmospheric dispersion modeling, multivariate statistics, or use of neural networks to incorporate site-specific information into the predictive process.